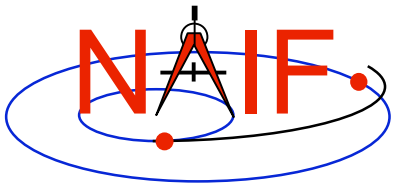
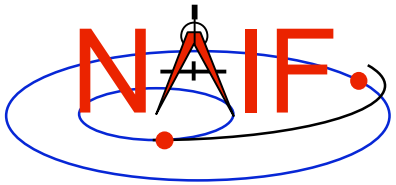


Navigation and Ancillary Information Facility

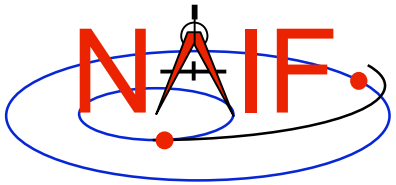
SPICE Event Finding Subsystem

January 2008



Topics

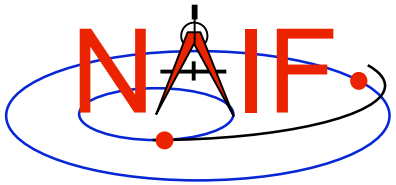
- Overview
- Eclipse Events
- Occultation Events
- Field-of-View Events
- Numeric Events
- Window Math



Overview

Navigation and Ancillary Information Facility

- The NAIF team is working to add a new subsystem to the SPICE Toolkits. This subsystem is designed to identify the times or time intervals of particular geometric events.
  - The Fortran and C Toolkits will contain all planned functionality.
  - Icy and Mice will include a subset of the planned functionality.
- The event subsystem algorithms detect four types of events:
  - Eclipse
  - Occultation
  - Field-of-View
  - Numerical
- The first three types describe a specific set of geometric conditions identified with the corresponding type name. The fourth type describes a geometric quantity satisfying a numeric relationship.
- Status
  - An alpha-test version should be available in the next six months.
  - NAIF has not determined a release date for the official new subsystem.



Eclipse -1

- **The eclipse detection algorithm identifies twelve eclipse configurations (as observed from the eclipsed body).**

- **Eclipse models assume a spherical shape for eclipser and eclipsed bodies. A sphere or point object can represent the illumination source.**

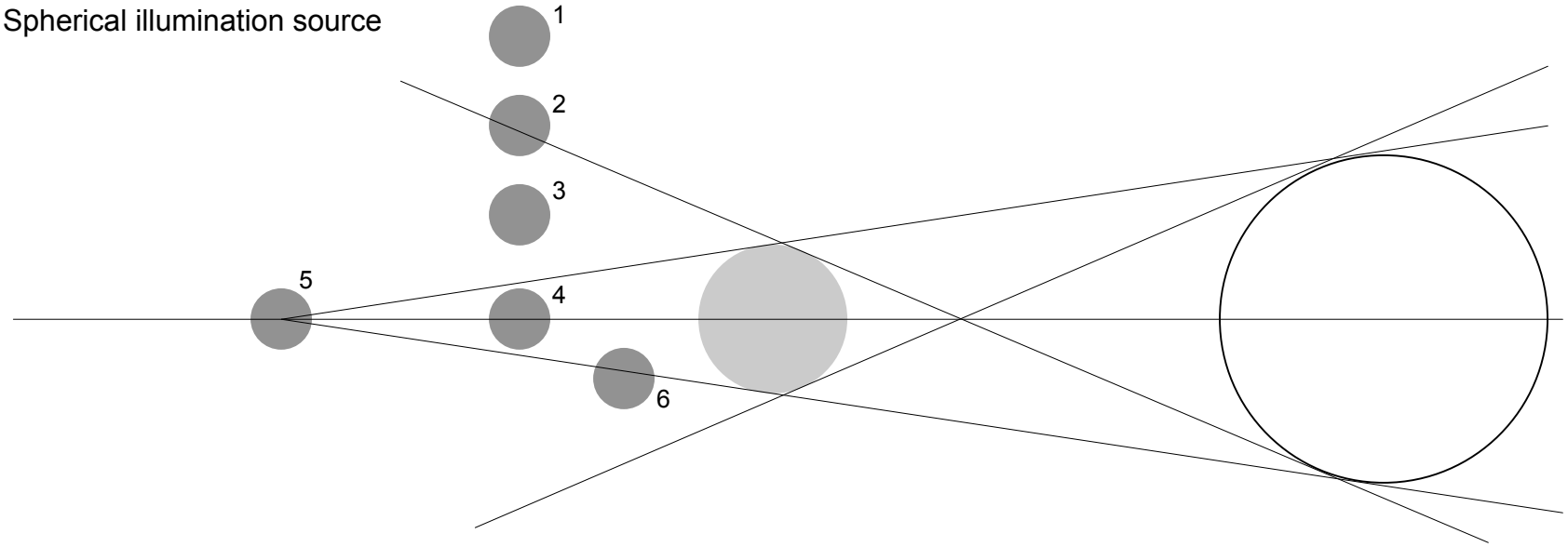
Eclipse - 2

Navigation and Ancillary Information Facility

Eclipsed body

Eclipser body

Spherical illumination source



1: Eclipsed body in full illumination
2: Eclipsed body partially illuminated, partially in the penumbra
3: Eclipsed body exclusively in the penumbra
4: Eclipsed body completely in the umbra (NAIF defines this state as also in the penumbra.)
5: Eclipsed body fully in penumbra with complete umbral shadow on body
6: Eclipsed body partially in penumbral and partially in umbral regions

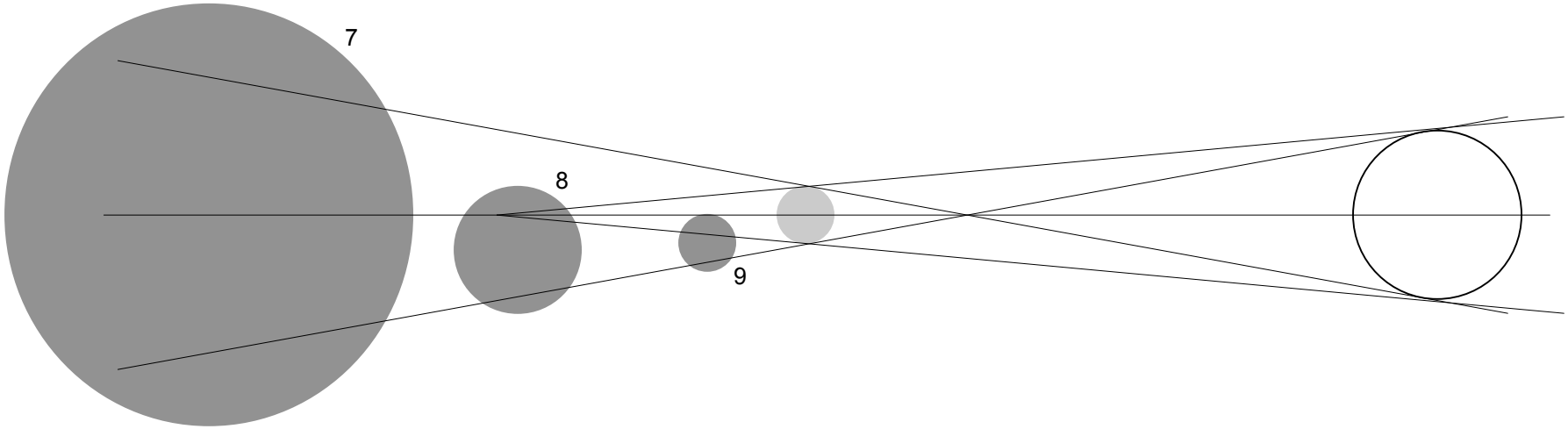
Eclipse - 3

Navigation and Ancillary Information Facility

Eclipsed body

Eclipser body

Spherical illumination source



7: Eclipsed body partially illuminated with the penumbral shadow completely on body, no umbral shadow

8: Eclipsed body in illuminated, penumbral, and umbral regions with full umbral shadow on body

9: Eclipsed body in illuminated, penumbral, and umbral regions without full umbral shadow on body

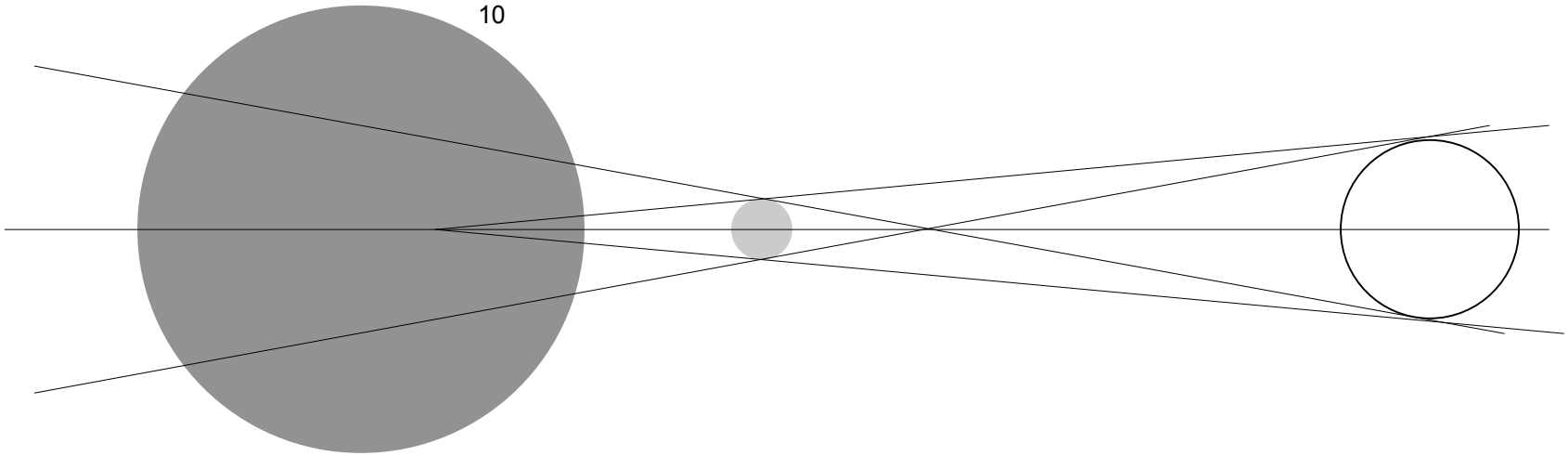
Eclipse - 4

Navigation and Ancillary Information Facility

Eclipsed body

Eclipser body

Spherical illumination source



10: Eclipsed body partially illuminated with the penumbral and umbral shadows both fully on body

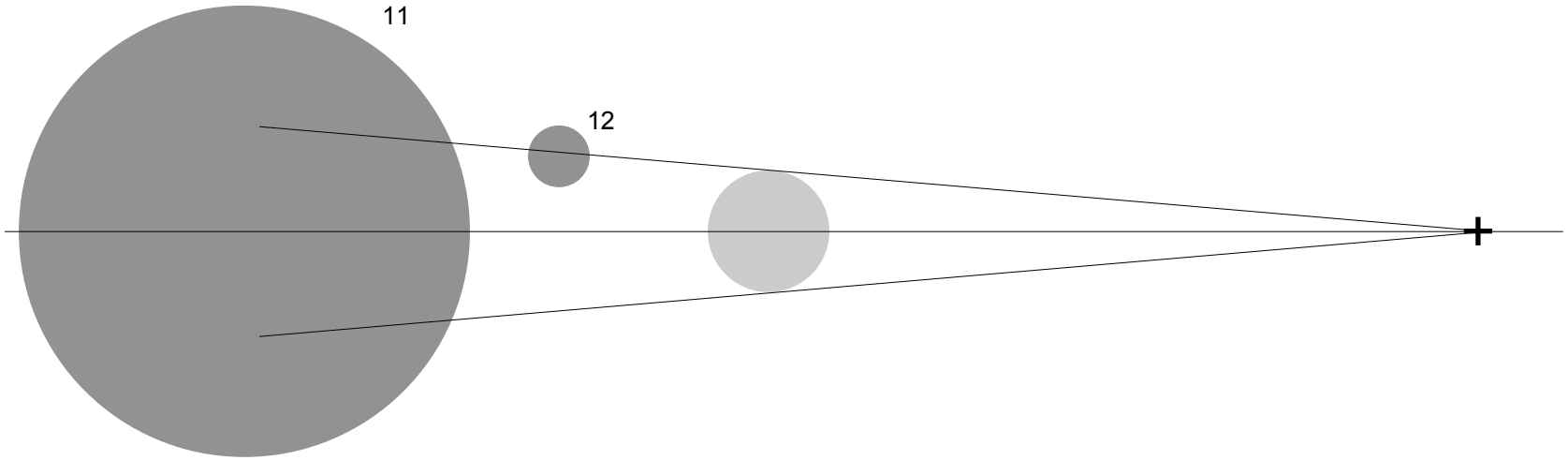
Eclipse - 5

Navigation and Ancillary Information Facility

Eclipsed body

Eclipser body

\+ Point illumination source



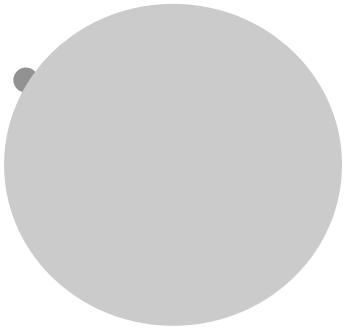
11: Eclipsed body partially illuminated with full umbral shadow on body, no penumbral shadow
12: Eclipsed body partially illuminated, partially in the umbra shadow, no penumbral shadow

Note, these configurations exist only for point illumination sources.

Occultation

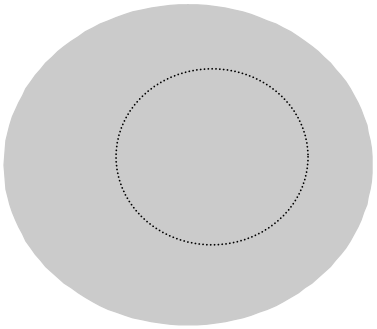
- **The occultation detection algorithm identifies configurations with a triaxial ellipsoid modeling the occulting body. A triaxial ellipsoid or point object models the occulted body.**

Point



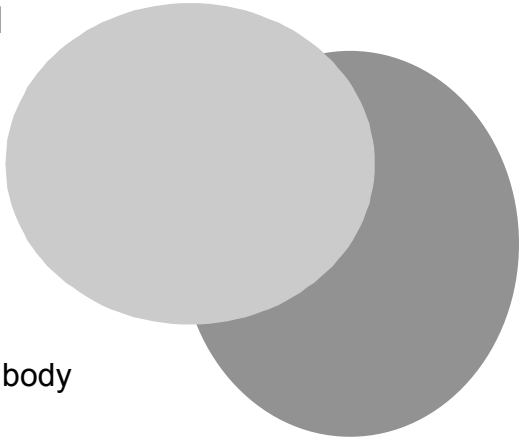
A point target occulted by a spheroid.

Full



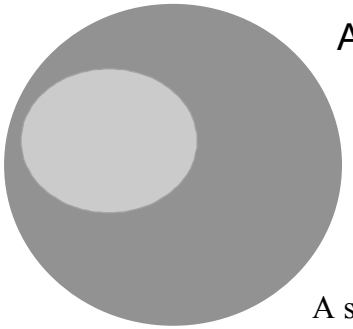
A spheroid fully occulting a second spheroid.

Partial



A spheroid partially occulting a second spheroid.

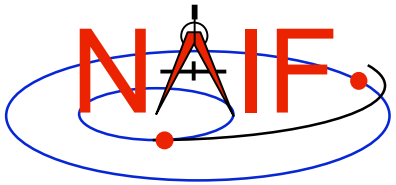
Annular



A smaller spheroid passing between a second, larger spheroid and the observer.

Occulted body

Occulting body



Field-of-View

- **The field-of-view detection algorithm identifies configurations where an instrument field-of-view intersects or contains a body of interest. The instrument's field-of-view properties are defined in a SPICE instrument kernel.**
  - **The field-of-view detection algorithms answer questions of the form:**
    - » ***"Given a time interval [t1, t2] and a body, at what times within [t1, t2] does the body intersect the instrument field-of-view?"*** **(Can I see it, if so, when?)**
  - **In order to answer questions of the form:**
    - » ***"Given a time interval [t1, t2] and a set of bodies, which bodies will intersect the instrument field-of-view across [t1, t2]?"*** **(What can I see?)**

    The user performs a field-of-view search over [t1, t2] for each body.

Numeric - 1

- **The numerical event detection algorithms identify configurations where a particular scalar geometric quantity satisfies some relationship, as defined by an operator and a reference value, or a unary operator.**
- **Geometric quantities:**
  - **Angular separation: observed angular separation between limbs**
  - **Angular speed: magnitude of angular velocity of apparent target about an observer**
  - **Angular rate: the time derivative of the apparent angular separation**
  - **Apparent angular diameter**
  - **Range: ||r||**
  - **Range rate: d(||r||)/dt**
  - **Elongation angle: Sun-observer-target angle**
  - **Phase angle: observer-target-Sun angle**
  - **Coordinate: an element of the position vector in a particular coordinate system and reference frame. The position vector is defined as either "observer to target" or "sub observer point on target."**
    - » **Coordinate systems and the corresponding coordinates:**

• RECTANGULAR:	**X,**	**Y,**	**Z**
• CYLINDRICAL:	**RANGE,**	**LONGITUDE,**	**Z**
• GEODETIC:	**LONGITUDE,**	**LATITUDE,**	**ALTITUDE**
• LATITUDINAL:	**RANGE,**	**LONGITUDE,**	**LATITUDE**
• RA/DEC:	**RANGE,**	**RIGHT_ASCENSION,**	**DECLINATION**
• SPHERICAL:	**RANGE,**	**COLATITUDE,**	**LONGITUDE**

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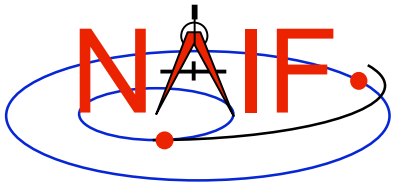
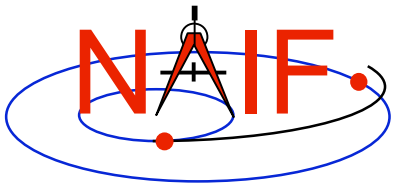


Numeric - 2

- **Applicable operators**:
  > (quantity > reference_value)
  = (quantity = reference_value)
  < (quantity < reference_value)
  ABSMAX (quantity)
  ABSMIN (quantity)
  LOCMAX (quantity)
  LOCMIN (quantity)
- **Examples of detectable events using a numeric event search:**
  - **periapsis or closest approach**
    - » **minimum distance between a body and center or between two bodies**
  - **apoapsis**
    - » **maximum distance between a body and center**
  - **pointing constraints**
    - » **angular separation between the look direction and Sun direction**
  - **boundary confinement**
    - » **a vehicle sub-point on a body lies within a latitude/longitude range**
  - **node crossings**
    - » **Z coordinate of a body position in equator based frame equals zero**

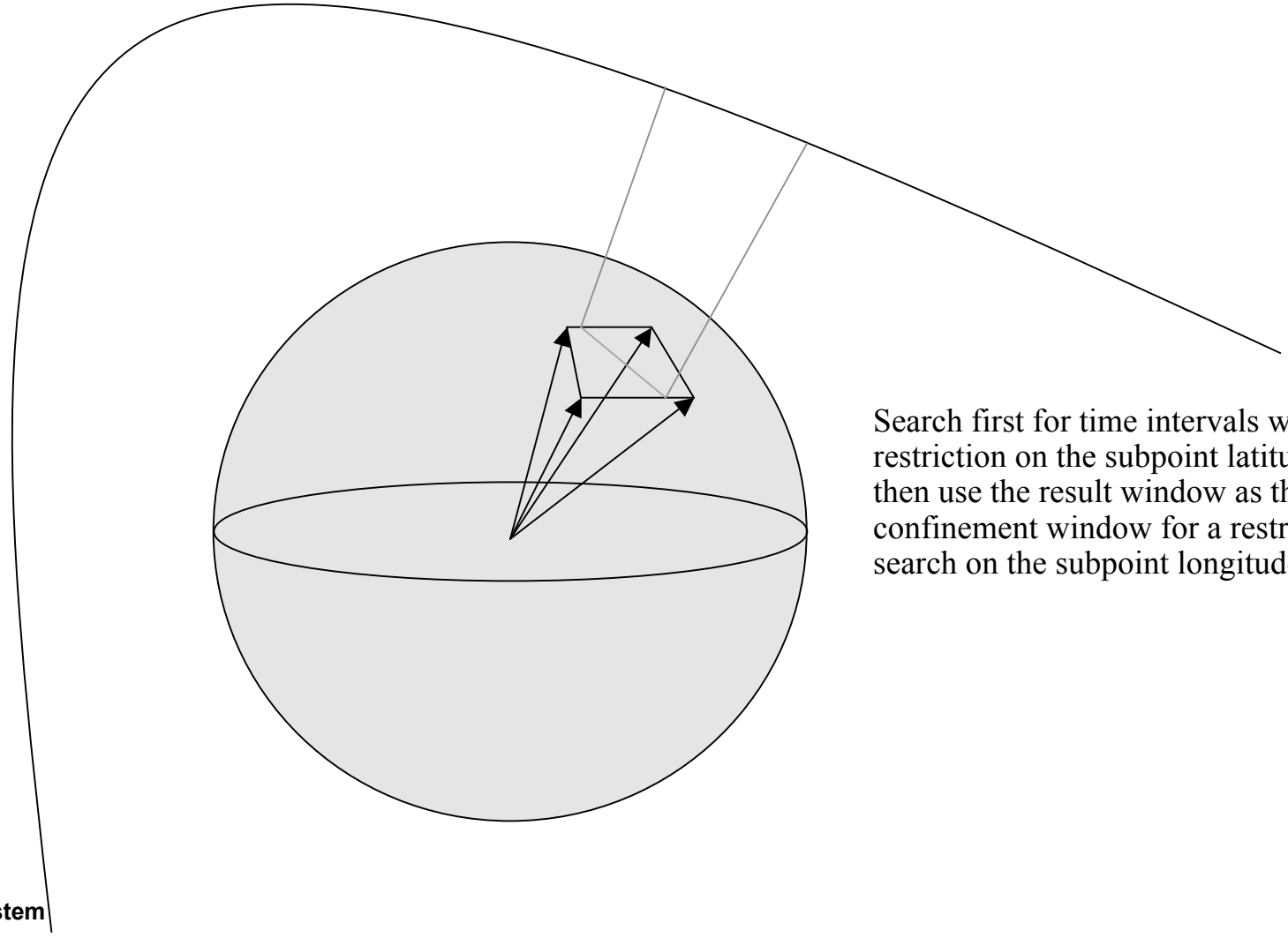


Windows Math

- The events subsystem uses the SPICE windows data type as an input, named the confinement window, to define the time intervals to search. A window is also used as an output, named the result window, during which the event of interest occurs.
  - Windows are collections of zero or more ordered, disjoint intervals of double precision numbers. The event finder subsystem uses windows to define the initial search times and final result times.
  - The Toolkit contains a family of routines for creating windows and performing "set arithmetic" on them (union, intersection, difference, etc.).
- This windows based implementation allows a user to perform multiple searches where the window result of one search is used as the input (confinement) for the next, either to satisfy a restriction on multiple conditions or as a refinement process.
  - Note, the physics of a multi-event geometry may be such that the search for one event will proceed faster than another and markedly reduce the measure of the search space for the next search.

Example - 1

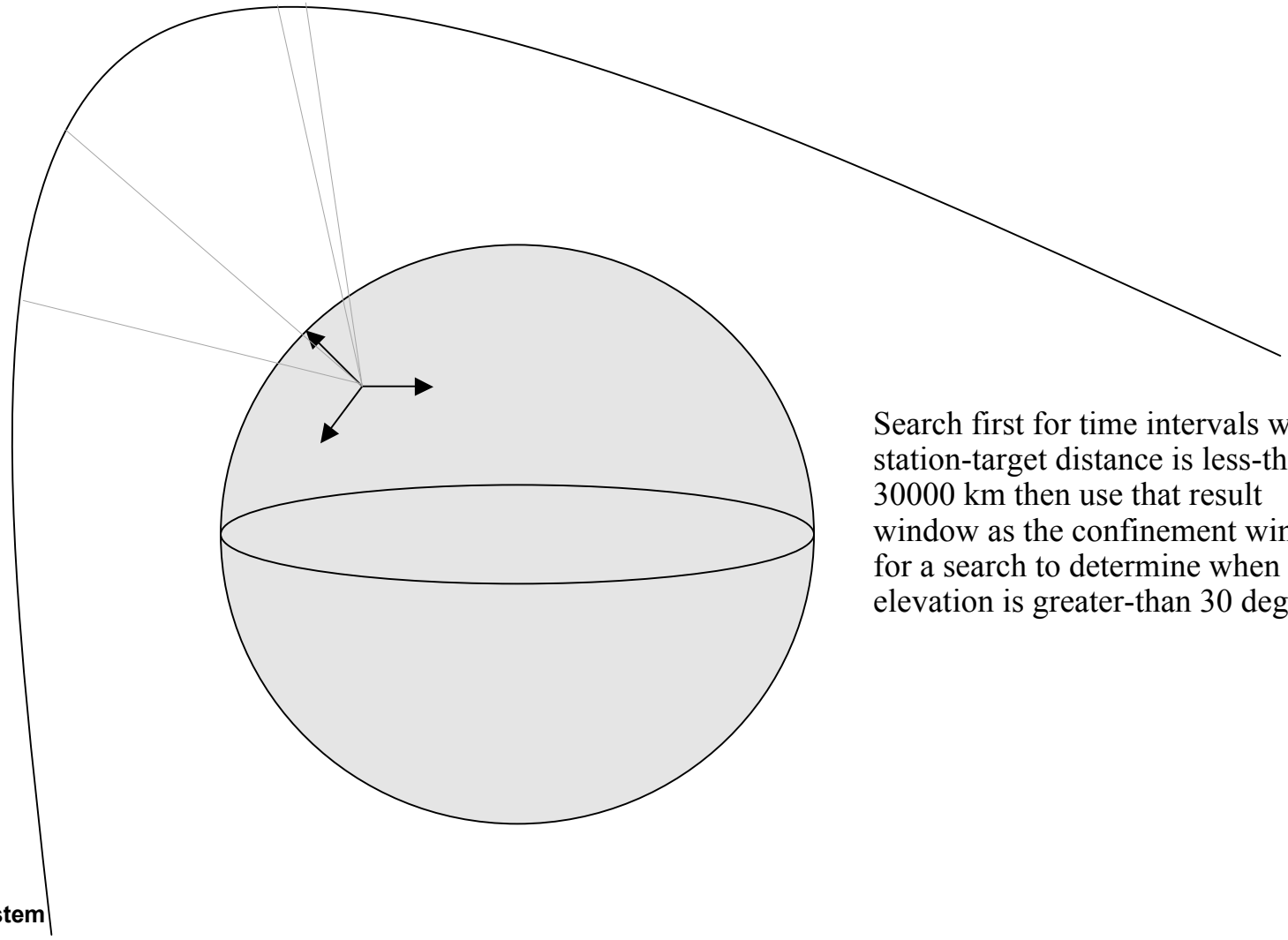
- **Time interval for which the subpoint of a vehicle passes through a latitude/longitude "box."**



Search first for time intervals with the restriction on the subpoint latitude, then use the result window as the confinement window for a restriction search on the subpoint longitude.

Example - 2

- **Time intervals for which an orbiter passes in line-of-sight of a station, with a local elevation above 30 degrees, with a maximum distance of 30000 km.**



Search first for time intervals where station-target distance is less-than 30000 km then use that result window as the confinement window for a search to determine when elevation is greater-than 30 degrees.